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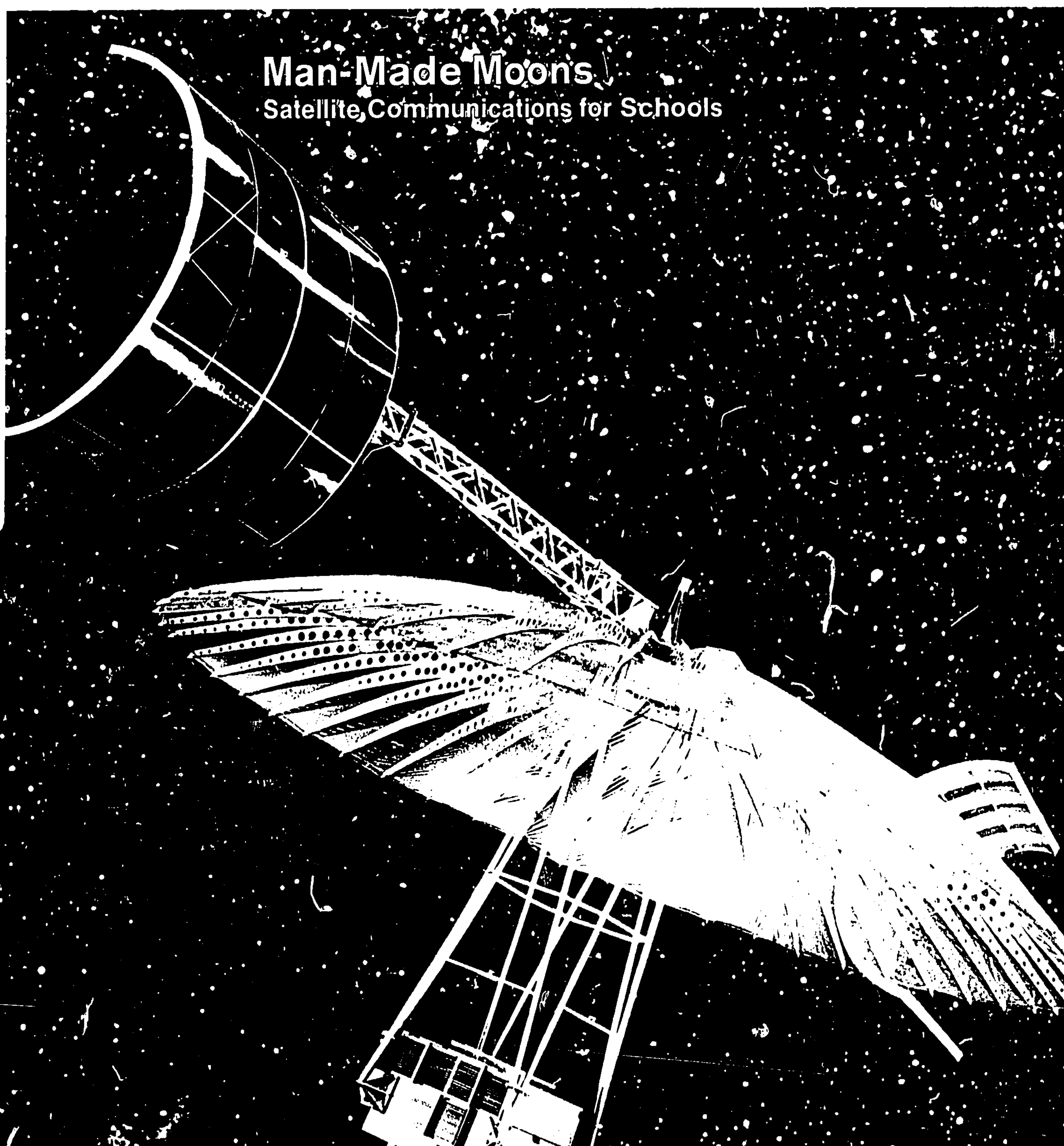
ABSTRACT

In an effort to prepare teachers for the coming changes in education caused by the rapidly developing communication satellite technology, this monograph offers a non-technical background to this new development. It begins by explaining the importance of such satellites and offers a layman's guide to the technology of satellite systems. It reviews the history of communication satellites and predicts that ATS-F, a NASA satellite scheduled to be launched in 1973, will be the beginning of a boom in satellite use in education. The direct effect of this boom on the classroom teacher is discussed, noting that satellites will bring the power of large, sophisticated computers to students and teachers whether in remote or urban areas. In talking about the problems of the ground links to the satellite, the monograph explains the problems caused by spillover, freeloading, copyright infringement, and institutional cooperation. Several policy questions raised by the use of satellites in education are explored. A glossary and other supplementary material is appended. (JY)

Man-Made Moons

Satellite Communications for Schools



nal Education Association Publication

Man-Made Moons

Man-Made Moons:
Satellite Communications for Schools

Foreword by

Sidney P. Marland, Jr.
U.S. Commissioner of Education
Washington, D.C.

Prepared by

Lawrence P. Grayson
Acting Director
Division of Technology Development
National Center for Educational Technology
U.S. Office of Education
Washington, D.C.

Frank W. Norwood
Executive Secretary
Joint Council on Educational Telecommunications
Washington, D.C.

Harold E. Wigren
Telecommunications Specialist
Division of Instruction and Professional Development
National Education Association
Washington, D.C.

nea
National Education Association
Washington, D.C. 20036

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Foreword

After years of peering somewhat nervously into the future and predicting the benefits to education that would accrue from the widespread use of various technologies, it comes as something of a surprise to realize that the future, in a sense, has arrived. Technology is no longer a matter for speculation but is a reality in classrooms across America. We have computer-assisted instruction. We have talking typewriters. We have televised instruction and tape-recorded lessons. We have machines that make it possible for children to learn individually and at their own pace. We have mechanical servants that obligingly repeat instructions and correct answers and do myriad other important but repetitive chores so that teachers are free to work more closely with students.

Now there appears on the horizon — or rather in the skies — a new and marvelously sophisticated piece of technology that has obvious potential for learning activities of all kinds: the educational satellite. Poised above the earth's atmosphere, a single satellite, properly placed, can relay information of all kinds to the entire United States, bringing instant information to previously inaccessible and thereby deprived communities of children and adults.

The careful examination of satellite communications for education offered in this booklet is both informative and timely. I say timely because the Office of Education, in conjunction with the National Aeronautics and Space Administration and the National Institutes of Health, has already invested substantially in a satellite-based education experiment in Alaska. At present we are funding various planning activities that will lead to more advanced experimentation via the ATS-F satellite NASA plans to launch in 1973.

Governmental interest in putting space technology to work for education does not, of course, assure the effective use of these new tools at the classroom level. In large measure that responsibility rests with individual teachers and administrators. For that reason, I commend this publication to you as an excellent introduction to the challenges and promises satellites for education hold for teaching and learning.

Sidney P. Marland, Jr.
U.S. Commissioner of Education

Preface

Twenty years from now historians will say that satellites changed our society as much in the seventies and the eighties as the airplane did in the fifties and the sixties. Satellites can carry any form of information that can be transmitted electronically. When we see on our television screens the words "Via Satellite," we think first of a means of transoceanic TV relay of the coronation of a world ruler, the Olympic Games, or man's giant step on the moon. But satellites are capable of much more than this.

Sometimes referred to as Switchboards in the Sky or as Space Telephone Poles, communications satellites are essentially signal repeaters whose height enables them to provide coverage over a very large area. They can be dedicated (designed for a single kind of service such as television relay) or they can be multipurpose (designed for such varied communications services as data transmission, computer linkage, information networking, television, or telephone and telegraph).

Perhaps most exciting, satellite technology is a major component of a burgeoning communications revolution in the worldwide transmission and distribution of information. The other components of this revolution are cable television, television cartridge and radio cassette systems, and computers. When satellites are combined with these technologies, a telecommunications system will eventuate that will make possible new dimensions in the storage, manipulation, and retrieval of information. It will be a system the range and possibilities of which cannot be matched or duplicated by existing ground transmission systems. Most particularly the marriage between satellites and cable television will open up fantastic possibilities in the exchange of materials and resources between schools in all parts of the nation and eventually the world. Satellites form the linkages that are essential to effective cohesion for the system — the tie that binds the pieces together. At one stroke, cities, towns, and isolated villages will become part of an educational network with a potential, the impact of which is indeed revolutionary. A few decades from now, when satellites can reach individual homes and schools directly, the word *isolated* may well be meaningless.

By placing the satellite in an orbit 22,300 miles above the equator, its period of rotation can be matched to the revolution of the earth, with the result that it will appear to stand still. Such synchronous orbits are possible only at the equatorial plane, but the advantage of this is that the earth station antennas can be fixed rather than movable. For such a geostationary orbit, each satellite can see one-third of the earth's surface; thus, a single satellite can cover all of the United States. A series of three or more such satellites interconnected could make possible a system of instantaneous global communications. The implications of such a capability are staggering. For the teacher, the communications satellite becomes an Aladdin's lamp through which he can command resources from over the entire globe. At long last, the teacher will be able to say: "The world is my classroom."

When these developments come to pass, the shaping of

government and educational policy concerning satellite communications will become one of the most important items for consideration of the education profession. As prime users of satellite communications in education, teachers have a considerable stake in decisions that are made about its development. NASA and the space industry are currently projecting their long-range schedule for satellite technology, and they are asking the education community to define its 30-year requirements for satellite space. The teaching profession, therefore, needs essential information about the issues and options available before it can make valid judgments and pronouncements in this area.

The objectives of this publication are threefold:

1. To alert teachers to the recent developments in satellite communications technology that have profound implications for education
2. To encourage teachers to take a leadership role in determining how satellites will be used in education and thereby determining education's future requirements for satellite space
3. To create an awareness on the part of teachers of the potentialities as well as the problems that satellite communications pose for education and an understanding of how satellites affect the role of the classroom teachers.

Education today is fortunate in having technology-oriented teachers who know that unless they are informed and take action, other groups will make decisions about these developments in satellite technology — decisions that may or may not help teachers improve instruction. Because of its ability to convey information instantaneously to points all around the globe, because of its ability to create communities based on interest and concern rather than ones based on accidents of geography, because of its ability to provide educators in isolated areas with the same sophisticated resources that are available to schools in more affluent communities, satellite communications technology has vast potential importance for teachers.

Communications satellites represent a quantum jump in the communications capability of our society. Not only will satellites extend present radio, television, telephone, teletype, and computer services, they will also fundamentally affect the basic structure of society. While this may appear to be fanciful, ninety years ago who could have predicted the impact of the telephone on our lives today? In the Middle Ages who could have foretold the effects of the printing press, particularly when so few people then were able to read? Few, if any, of all the early science fiction writers who speculated about man's first visit to the moon foresaw that the world would watch the event on live TV.

Satellites are the fourth major revolution in man's ability to communicate, comparable in effect to the development of speech, writing, and printing. Because they can provide widespread instantaneous communication, satellites have significant implications for society in general and for education in particular. The Department of Health, Education, and Welfare recently said that "the existence of a nationwide communication system capable of effectively and economically reaching the general public is a precondition for any successful program in consumer protection, preservation of the environment, health and nutritional awareness, job opportunity programs, and preschool, adult, and vocational education."

A satellite can reach areas of a million or more square miles, or it can broadcast selectively to smaller specified areas.

Chapter

Why Are Satellites Important? 1

It offers easy access to regions that would be very impractical, very difficult, or very expensive to reach by ground communications systems such as the telephone. A satellite can reach isolated, mobile, and dispersed populations as easily and as inexpensively as it can reach dense population centers. Because it operates on electronic impulses, a satellite can handle telephone, telegraph, radio, television, facsimile, and computer data services with equal facility. Satellites can truly be viewed as a man-made national or even worldwide resource.

Satellites will not be the only communications devices to revolutionize education. Rather, the satellite will be a key ingredient in a technological mix that involves microforms, computers, cable systems, and video cassettes. Together these devices will make particular resources accessible to anyone who needs them, when he needs them. Microforms, for example, make it possible to transport the holdings of entire libraries of a million or more volumes to locations that currently have limited library resources. Computers can provide a high degree of selectivity and responsiveness so that the proper resources — materials, techniques, and persons — can be identified and made available to the student or teacher to solve a particular learning problem at a particular time. Urban areas of the future can be wired with cable systems of 40 to 200 channels that will connect homes, schools, community centers, libraries, and other places where people gather to learn. With two-way capability between a learning station located even in a private home and a resource center housed in a school or library, it will be possible to provide television, voice, and computer-data services tailored to meet local and individual needs. With video cassettes, materials can be stored so that the student and the teacher can use them whenever they want.

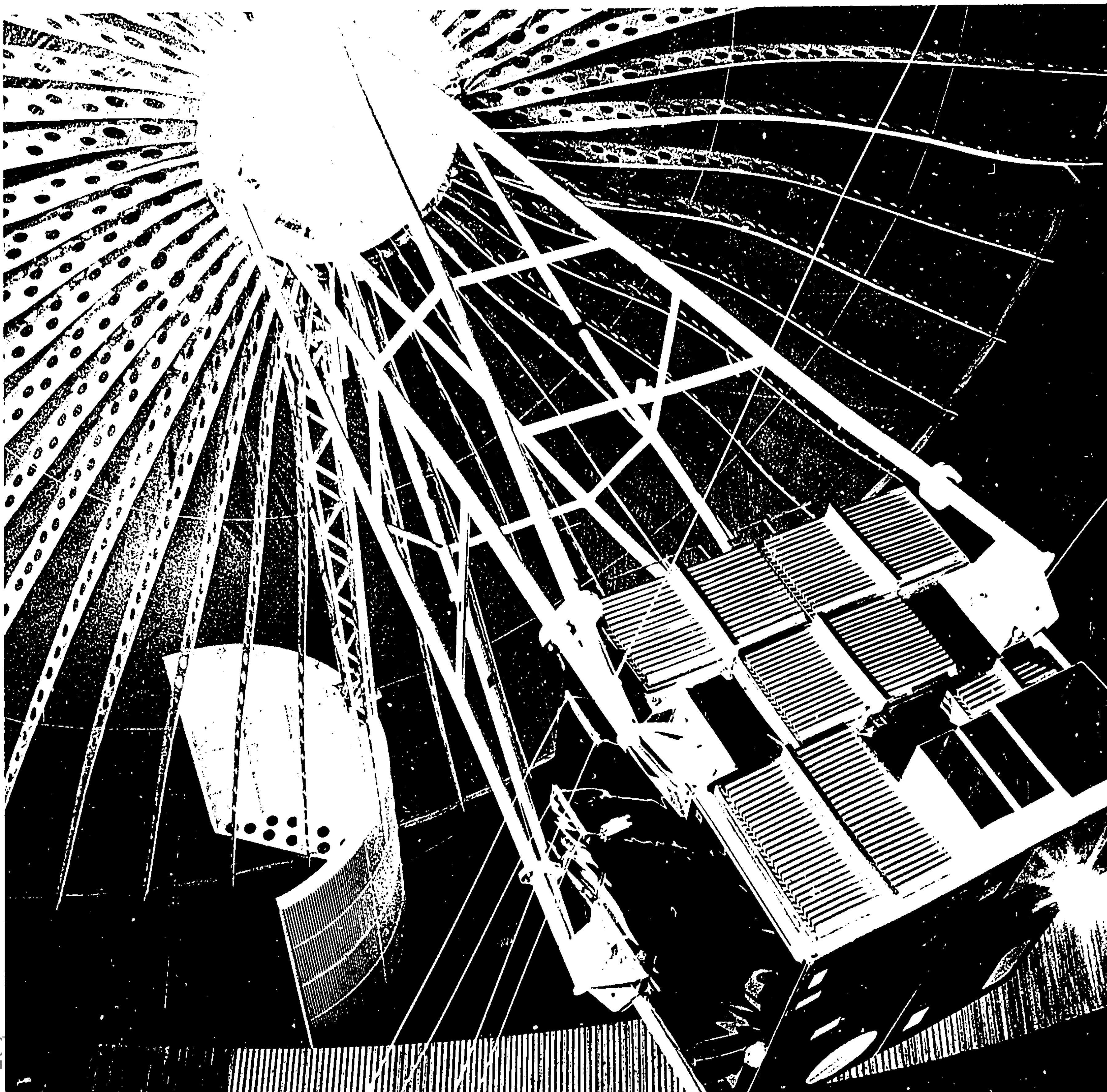
A satellite can interconnect the wired cities one to another for intercity communications; it can beam educational television programs to large geographic areas, such as the Rocky Mountains region, Alaska,

Appalachia, or to the entire nation; and it can permit local or district resource centers to have access to statewide, regional, or national banks of instructional materials. *The satellite is the key in making specialized resources from many places available wherever they are needed.*

These capabilities and potentialities are almost on us. Technological progress in this country has been rapid and is still accelerating. While it took 112 years for photography to move from the discovery of its basic principles (in 1727) to the manufacture of the first camera (in 1839), that time span was reduced to 35 years for radio (1867-1902), to 12 years for television (1922-34), to 3 years for the integrated circuit (1958-61).

Satellite technology is growing just as rapidly. In 1965 the global communications system operated by Comsat (Communications Satellite Corporation) consisted of one satellite — Early Bird — with one antenna located in North America and one in Western Europe. By the end of 1970, the system had expanded to 5 satellites and 51 antennas directly linking 30 nations located on every continent except Antarctica.

Although satellite development is still in its infancy, it is clear that satellites will soon be ready for education. The question is, When will education be ready for satellites?



Before defining a rash of technical terms that turn out to be not nearly so formidable as they look, it may be well to begin with an examination of what satellites do and why their role in communications for all purposes is increasingly important. The need for communications satellites is based in a simple fact: television signals travel in a straight line. Unlike shortwave radio which can send a signal around the globe, television travels in a straight line-of-sight to the horizon and continues on in a tangent to the curved surface of the earth. No increase in transmitter power can extend the coverage of the TV signal beyond the horizon. What does make a difference is the height of the TV transmitter. The higher the transmitter, the farther it can see, which is why television broadcast stations build tall towers or locate their transmitters atop buildings like the Empire State in New York or on high ground like Mt. Wilson just outside Los Angeles.

Clearly, there are limitations as to how high a tower can be built, and not all mountains are as conveniently located as Mt. Wilson. To send television programs and other traffic between cities, the telephone company has constructed a network of microwave relay stations. From New York to Los Angeles, for example, programs are sent by the Bell System in a series of 40-mile hops. Each relay station can receive a program from a station near its eastern horizon, amplify it, and retransmit it to another relay tower to the west. Many such microwave relay stations criss-cross the United States carrying long distance phone calls, television, computer communications, and the like. Because these relay stations operate at microwave, rather than broadcast, frequencies, the television traffic they carry cannot be received by viewers at home until it is retransmitted by their local broadcasting station.

Intercity microwave relay is a satisfactory solution to the problem of getting television signals from Maine to California and from Oregon to Florida, but no help at all when one wants to transmit television from London to New York. Building 1,000-foot towers across the Atlantic or

Chapter

Satellite Systems— Uplinks, Transponders, and Downlinks 2

Pacific Ocean is simply not possible. *Unfortunately, the trans-Atlantic cables that carry telephone and telegraph messages are not suitable for television transmission.* Improbable as it may sound, the more practical approach is to establish one microwave relay so high that its line-of-sight enables it to see London to the east and New York to the west. That relay station is, of course, not some modern-day tower of Babel, but the communications satellite.

Since 1957, when the Soviet Union startled the world by launching Sputnik, the first successful man-made satellite, it has been apparent that what goes up need not necessarily come down. In orbit far above the earth's surface, a satellite can act exactly as an incredibly tall microwave tower would act, receiving a message from one continent and retransmitting it to another.

All satellites — including our only natural satellite, the moon — revolve around the earth. How long it takes a satellite to make one complete revolution about the earth is a function of its distance from the earth's surface. The moon, 239,000 miles away, takes 28 days to make one revolution around the earth. Early satellites, only a few hundred or a few thousand miles from the earth's surface, revolved around the earth at such high speed that they appeared to streak from one horizon to the other in a matter of a few hours.

In 1963, the United States launched a satellite that did much to make satellite communications a practical matter. The engineer's term — *geostationary orbit at synchronous altitude* — sounds frighteningly technical. All that it means is that if a satellite is placed in orbit 22,300 miles over the earth's equator, the time it takes to make one revolution around the earth will be precisely equal to the time it takes the earth to make one rotation on its own axis. As an analogy, one might imagine a small boy running along beside a merry-go-round; if his speed is synchronized to the speed the merry-go-round is turning, his friends on the carousel can keep him in view without moving their heads.

A communications satellite in synchronous orbit moves in lockstep with the earth below and so appears to be "geostationary" — standing still in the sky when viewed from the earth below. NASA's 1963 satellite, Syncom (for synchronous communications satellite), first demonstrated the great advantages a geostationary satellite can offer.

Like a terrestrial microwave tower, a satellite is only a relay device for messages transmitted to it. A satellite uplink is merely the transmitter on earth that beams a message to the satellite. On board the satellite, a transponder — a combination receiver-and-trans-

mitter — receives the message, amplifies it, and retransmits it on another frequency to a receiving station below. As the earth-to-satellite path is the uplink, so the satellite-to-earth path is the downlink. The transponders on board the satellite may be likened to a switchboard in the sky.

With that function in mind, it is easy to see the great advantage that synchronous satellites offer. Because the satellite appears to be permanently located at one spot above the earth's surface, it is possible for the transmitters and receivers on the ground (earth terminals) to be aimed at the satellite and locked down. Satellites that are not geostationary require earth terminals that can track them as they appear to move across the sky.

There is a further advantage in geostationary satellites. From 22,300 miles up a satellite can see something more than one-third of the earth below. Thus, three satellites evenly spaced around the equator can provide communications to any point on the world below.

The Intelsat system (the global communications system of the International Telecommunications Satellite Consortium of which the USA's Communications Satellite Corporation is managing partner) works in just this way. Intelsat is designed to provide a means by which existing terrestrial communications systems can be interconnected. The Intelsat system is designed to complement rather than replace existing terrestrial services. As a "carrier's carrier" supplying communications services wholesale to common carriers such as Bell and Western Union, Intelsat has designed its satellite system to play that role with maximum efficiency and at minimum cost. The result is that the Intelsat system, which requires fewer than 100 earth terminals to connect with existing terrestrial systems, can afford to invest hundreds of thousands or even millions of dollars in such ground installations. Educational users, on the other hand, are more likely to be interested in satellite systems that can serve thousands of earth terminals at schools, hospitals and medical centers, universities, and libraries. Such a satellite system is well within the state of the art, but requires starting from different first premises.

If there are to be many ground terminals, most of which need only to be capable of receiving signals from the satellite, then the best system is one that builds the most powerful satellite possible in order that the receive-only terminals can be made small and relatively inexpensive. The National Aeronautics and Space Administration's ATS-F will pioneer such space technology. ATS-F — for Applications Technology Satellite (the letter *F* indicates that it is the sixth in that

series) — is scheduled to be launched in 1973. It will include equipment for the conducting of more than twenty experiments of which two are of particular interest to educators. In the United States, and later in India, high-powered television transponders (devices that receive television signals from the ground and retransmit them to receivers below) will be used to broadcast television programs from the satellite. The general public will not be able to receive the satellite transmissions directly, but inexpensive earth terminals will be established at community viewing centers, or conventional TV stations will rebroadcast the satellite transmissions, and — in this country — at CATV head-ends so that the programing can be transmitted to schools and homes by cable.

Essential to the development of a satellite strong enough to be received on inexpensive ground terminals is the use in ATS-F of a huge reflector, 30 feet in diameter, which will focus all of the transmitted energy onto a relatively small area below. The illustration on the cover of this book shows how ATS-F will look after its parabolic antenna has been unfurled in space. Exactly as a searchlight reflector focuses a beam of light, so the energy of the television transponders will be concentrated.

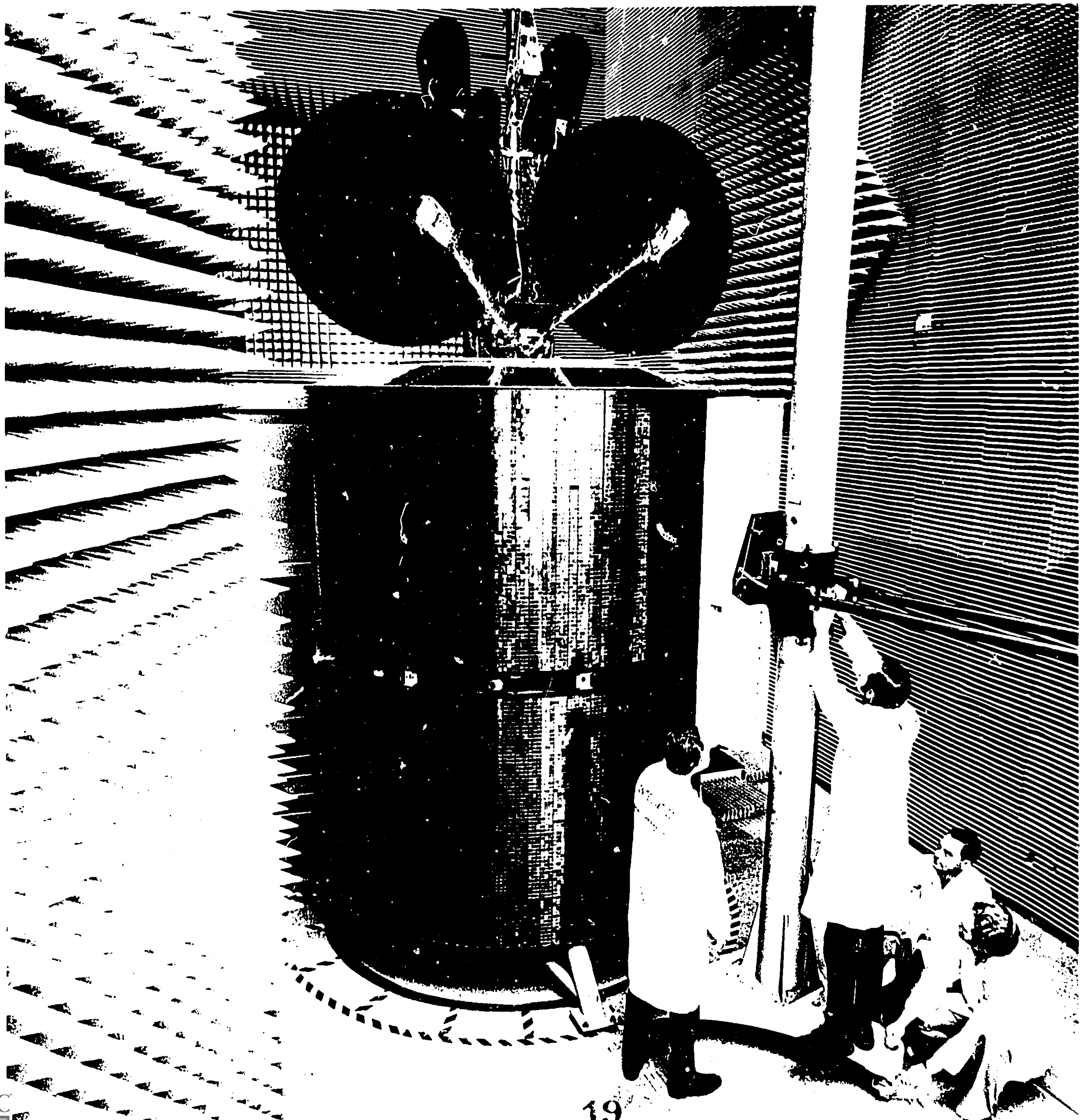
The Indian experiment mentioned above, called SITE for "Satellite Instructional Television Experiment," represents a cooperative effort between NASA and various agencies in the government of India. Indian authorities will be responsible for all of the costs and all of the decisions regarding programs and utilization. NASA is supplying the use of the satellite in order to gain firsthand knowledge about space-borne television transmission in the UHF band.

For a long while, it appeared that American educators would merely be bystanders. The UHF band which can be used in India is not available for satellite transmissions in this country because of the potential interference with the conventional UHF TV broadcast stations. What United States educational interests have long needed is permission to operate satellite experiments in a band in which no such constraints exist. Such a band exists at 2500 MHz, a piece of the spectrum that American educators already occupy for the Instructional Television Fixed Service (ITFS). Because ITFS systems use highly directionalized receiving antennas, possible interference between satellite transmissions and terrestrial ITFS can be avoided. The Joint Council on Educational Telecommunications, the National Education Association, the Department of Health, Education, and Welfare, and other educational and public broadcasting interests convinced the Federal Communications Commission and the U.S. State

Department to seek allocation of these frequencies on a worldwide basis at the 1971 Conference of the International Telecommunications Union. The ITU — a UN member agency — concurred, and in mid-1971 the way was cleared for the addition of a 2500 MHz TV experiment on ATS-F for the United States.

The Federation of Rocky Mountain States has received funding from the Department of Health, Education, and Welfare to undertake a comprehensive planning effort for educational experiments on ATS-F. As this book goes to press, smaller grants have also been made to the Appalachian Regional Commission and to educational authorities in Alaska to allow them to explore the possibility of ATS-F experiments in those areas. Cutting across the particular needs of regional interests, the National Education Association has developed a "Proposal To Expand Professional Development Opportunities for Teachers in Sparsely Populated Areas." The NEA's plan to apply space communications technology to helping rural teachers is described in the next chapter.

The technology of communications satellites is of less importance to American educators than what the satellites can do. The significant fact to keep in mind is that the communications satellites that bring us the Olympics from Japan or the President's visit to Peking represent only a first step in the communications satellite's potential contributions to education and information. The technology is already evolving which will reduce the cost of receive-only earth terminals from more than $100,000 to less than $1,000. With a satellite system designed to meet education's needs, the rural schoolhouse with a satellite antenna on its roof may be as rich in educational resources as the school in well-to-do suburbia.



It is happening now. As early as 1958, President Eisenhower's Christmas greetings were presented to the world by the satellite SCORE. By April 1962, the first television pictures to be transmitted by satellite were sent from California to Massachusetts. A few months later the launching of Telstar I made possible reliable trans-Atlantic television transmission. Since then, an increasing number of communications satellites with a variety of names and with increasing capabilities have been put into orbit. The latest ones are being, and will continue to be, used for educational experiments.

The 1970's will be *the* decade for satellite experimentation for education. In March 1971, a series of radio broadcasts and facsimile transmissions were sent between schools and libraries located on various islands in the state of Hawaii. This will be extended to 15 universities in the Pacific Basin area, including Alaska. This will make possible the regular two-way transmission of information by voice, data, and facsimile, and will enable educational institutions in the Pacific to share scarce, costly resources, and will extend the availability of education to remote islands. This exchange was accomplished using ATS-I,

Chapter

When Will It Happen? 3

a satellite launched by the National Aeronautics and Space Administration. The same satellite is also being used for a series of two-way radio broadcasts connecting the city of Fairbanks with about sixteen remote villages in Alaska. These broadcasts are providing in-service training and other support activities for teachers, as well as a mechanism for conducting forums on educational and native cultural topics.

ATS-F, a NASA satellite scheduled to be launched in 1973, will carry out several educational experiments. The U.S. Office of Education, in conjunction with NASA and various groups in the Rocky Mountains, Appalachia, and Alaska, is planning a series of experiments for 1973-74. Educational television programs are being planned for broadcast to the eight-state Rocky Mountain region.

These programs will be designed to meet various educational needs, such as career education, environmental awareness, and preschool skills, at all levels from preschool to elementary, secondary, higher, and adult. In Appalachia, the satellite may function to interconnect the earth-based communications systems, such as educational television and radio stations, cable systems, and computer centers, that already exist in the area.

The NEA experiment mentioned in the previous chapter is designed to address itself to improving the often-impaired quality of instruction in rural areas of the United States, where teachers often find themselves isolated from their colleagues and from the mainstream of educational advance and innovation. NEA has proposed that NASA grant it use, without charge, of the ATS-F satellite and of the NASA-operated earth stations.

If granted, NEA would then use the ATS-F satellite to transmit one 45-minute television program per week during the 1973-74 school year (September 1973 — May 1974) for a total of 30 programs. Each program would be preceded and followed by activities that would serve to increase its impact. Guides, reading lists, and bulletins for each program would be mailed to the audience well before broadcasting. After each program the viewing teachers would have a 45-minute (or longer) discussion. Verbal feedback to the program's originating point — for questions or further discussion — would be provided.

One of the most ambitious educational experiments has been scheduled to happen in India. Under an international agreement, NASA will move the ATS-F satellite from the position in which it serves the United States to a position over India, thus providing India with one television channel for four to six hours a day for one year. The government of India will conduct a series of large-scale experiments in which programing will be broadcast from Ahmedabad to more than 5,000

receivers throughout the country. These programs will be aimed at developing techniques to raise the level of basic hygiene, to increase agricultural productivity, and to provide basic literacy training by improving language fundamentals and reading skills. Large receivers in metropolitan areas will be connected to television stations that will rebroadcast the programs so that they can be received throughout those areas. In addition, small community receiving antennas will be distributed to some 2,000 villages for direct reception from the satellite.

One of the significant aspects of this experiment, from the point of view of education, is the low cost of the ground antennas. The proposed antenna, which measures 10 feet in diameter, will be constructed as a simple brass frame covered with chicken wire. In production, the unit cost is projected to be about $75 — a price that schools can afford.

ATS-G, to be launched by NASA in 1975, already is being considered for educational experiments. The NEA will continue to work with the U.S. Office of Education, NASA, and appropriate school and teacher groups to develop and refine a set of meaningful experiments to improve educational opportunities throughout this country, and will assist teachers in having a meaningful role in determining future satellite applications in education.

The factors that will limit the use of satellites in education are not technical, nor even educational — good programing, although expensive, can be produced. The limitations are economic (schools must be able to afford the costs) and political (the various organizations and jurisdictions involved must agree on numerous points, such as content, time of delivery, who originates broadcasts, etc.). These obstacles can be overcome only if teachers and the interested organizations work together.


YOUR PROGRAM
Press the reset button.
Dial your assigned number.
Wait at least 60 seconds.
If it does not come on.
Repeat steps 1.2.&3.
If it still does not come on,
phone the center.
B5

Technology and the Teacher

Chapter 4

As a teacher you can get ready for the future application of satellites and advanced technology to education. The role that you will assume depends, of course, on the way you view technology. Like any new method or technique, technology must serve the purpose for which it was intended. Any innovation, however, may not only be a new way to achieve a goal, but may also change the goal itself. In discovery methods, for instance, the learning of facts is often less important than the ability of a student to construct hypotheses, to weigh evidence, and generally to think.

It is fairly easy to predict the effect of technology *in* education. This is straightforward: teachers and administrators must determine how best to utilize technological resources as means toward achieving agreed upon goals and objectives. The effect of technology *on* education, however, is a societal problem involving the goals to be established and the values used to establish them. In this area, parents and students have key roles with teachers, administrators, legal authorities, and others working with them to determine the ends to be achieved.

With regard to the use of technology in education, the teacher must determine precisely how it will be used in the classroom to achieve specific learning outcomes. Teachers must be able to write clear objectives on what is to be learned, and they must be able to do so in measurable terms that allow them to determine

whether the learning has or has not taken place. Teachers must also improve their capabilities to evaluate student performance and their abilities to prescribe tasks that can help their students reach objectives. These skills can be improved through a combination of in-service training and continual practice. These skills, while essential for the proper use of technology in the classroom, are very appropriate and useful for the classrooms of today.

If the resources that a satellite can make available to the classrooms are to be used imaginatively and effectively, then teachers, administrators, curriculum designers, and producers must work together. Teachers must ensure that they are partners in the development of the satellite applications, and that they are not simply approached as a group to be sold on a new approach.

When the effects of technology *on* education are considered, the responsibilities of the teacher change. Often the assumption is made that if a parent or community group resists an innovation, they do not understand the consequences and benefits of the new approach. Rather, resistance may occur because they *do* know the implications of the change and do not want the change. Many people, for instance, see television as a marvelous resource that can provide a wide range of educational programing. Other people are equally convinced that television can be detrimental to their wishes and beliefs by exposing their children to situations and experiences that conflict with their culture and values.

There is no reason why one view or the other should prevail. In this country, education is based on local autonomy. Just as the elders in many churches set requirements for their clergy and then search for the proper person to fill the position, so too local communities should set the criteria and standards for their schools and then determine the role that technology should play within those bounds. For example, Montgomery County, Maryland, has proposed to establish a paired-school structure, in which each locality will have two schools — one traditional and one innovative — with the parents deciding which school their children will attend.

Teachers are in a key position with regard to the adoption of new educational technologies. They must work closely with the students and their parents to determine what they want, need, and hope for, and they must also work to ensure that the technological applications that are introduced into their classrooms achieve the desired results.

This is the background, but what about the particulars?

After teachers and administrators and parents have arrived at goals and objectives for the new technologies, how will what happens in the classroom be changed?

For one thing, in the satellite-linked, technology-oriented classroom of the future, rather than primarily dispensing facts and prescribing rote activities, the teacher will become more of a conductor of activities and an orchestrator of learning materials. Computers and special mechanized devices will handle drill and practice routines. Technology will enable the teacher to spend more time analyzing pupil difficulties and prescribing appropriate future learning sequences. Because of technology he will be able to work more closely with individual students.

Technology can provide the teacher with information and materials in various media on call and can extend his reach via telelectures. Computer simulations can provide responsive environments for students; a wide variety of computer-based information can be patterned to the requirements of individual students and teachers. These developments are not mere possibilities: they are realities. Although most or all of these applications exist today using ground-based communication, *they can be extended and made more widely available at a lower cost through satellites.*

Telephone and television transmissions can increase the quality of direct classroom presentations in areas where there are too few or no qualified teachers at all. Eventually, by 1985, when direct satellite-to-home or -school communication becomes technically feasible, television broadcasts can originate at a school or university or instructional center and then be transmitted via satellite directly to classrooms throughout the country. Until that time, the satellite can beam to the head end of a cable system and accomplish the same purpose. In a classroom, for example, in a rural area, a teacher or perhaps a teacher's aide can formally conduct the class, elaborating on and discussing the presentation and answering simple questions that may arise. If more detail is wanted about any point or if the teacher is unable to answer a question, an available telephone channel will allow the aide to talk to the master television teacher or to a specialist at the instructional center. If classes are composed of about 40 students each and there are five classes on a party line to the same specialists, it is conceivable that 100,000 students in small groups can be reached by the television teacher with the assistance of 500 specialists. The questions that are telephoned to the instructional center could be sorted and the television teacher could respond in his next telecast to the more

frequent and significant ones. In this way, the influence of quality teachers can be magnified by enlarging the size of their audiences. One master teacher can make a presentation to many students, yet do so as if he were instructing a small group.

In addition to providing direct instruction, the satellite can assist the classroom teacher by providing him with a means for obtaining additional information about his class, assistance in diagnosing the difficulties of individual students or of the entire class, prescriptions for remedial or additional work, and information about classroom management and school administration. These resource services can be provided on an overnight basis. Using typewriter-like and computer printing devices in conjunction with facsimile equipment located in Downey, California, and more remote schools, a central resource center can accept requests from teachers and administrators at the end of a school day; process the requests; and that night transmit printed matter, photographs, charts, and drawings to schools for use the next day.

Small group communications involving teachers at various locations can be established by using the telephone facilities in a teleconference mode. For instance, lectures can be presented by two-way telephone channels to provide short courses or seminars to specialized groups. Necessary printed or visual material in the form of pictures, slides, or charts can be organized in advance for delivery by a mail or facsimile system to the various locations prior to the lecture. Then at an appointed time all participating teachers are linked into a common network so that they can converse with the lecturer or directly with each other.

This approach has already been demonstrated with existing telephone facilities. In Brooklyn, New York, as well as in Los Angeles, Oakland, and recently in Overland Park, Kansas, teleclasses have been conducted as part of the normal educational activities, offering the regular school curriculum to homebound students, all of whom are either permanently handicapped or temporarily disabled. The approach has been enthusiastically accepted by parents, teachers, and students alike.

The same telephone channels can also be used for conferences. Teachers can discuss new techniques or difficult educational problems with each other and with specialists located at a center or university. Further, the satellite communications network can allow educators to collaborate on the planning of national educational

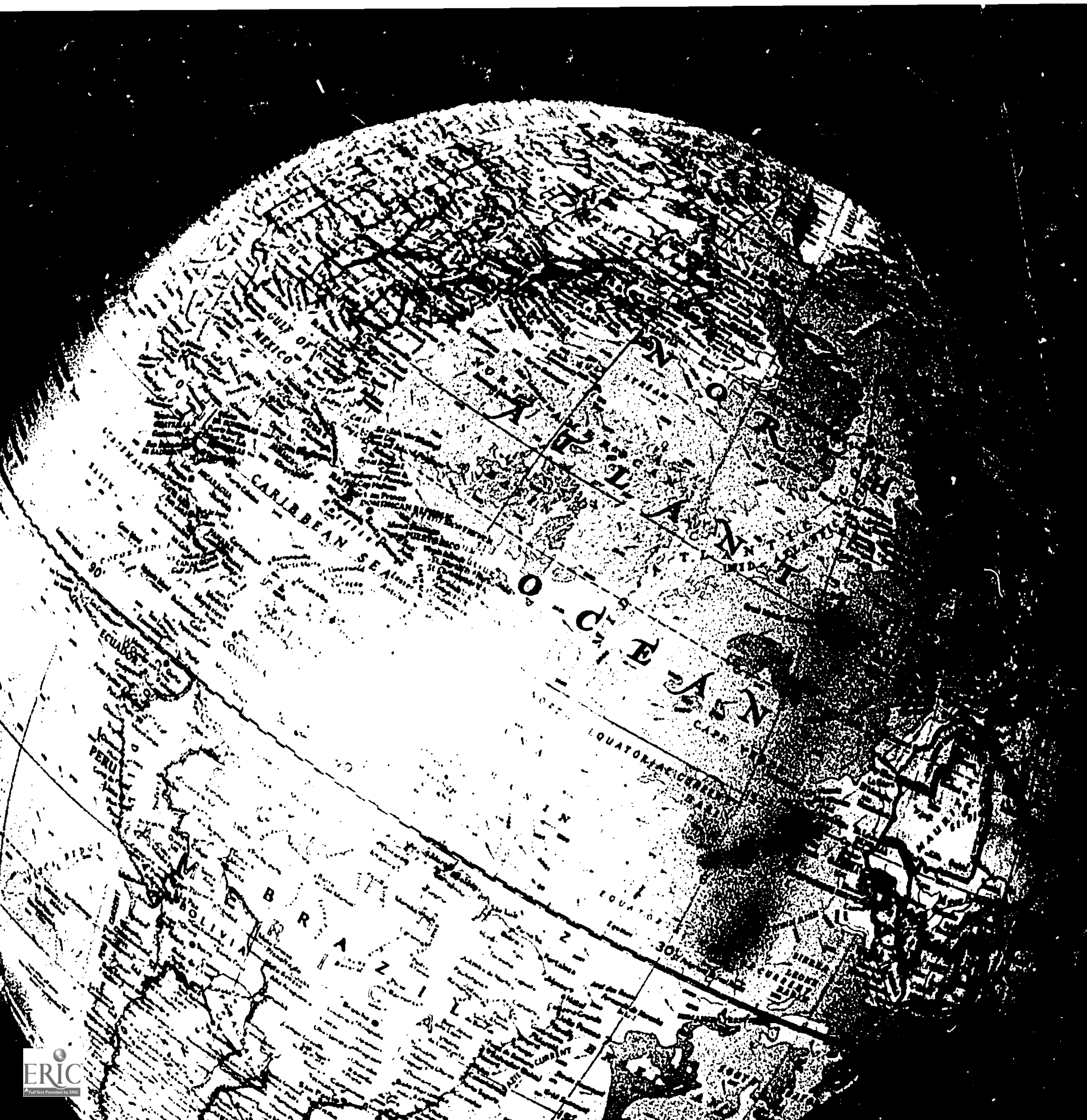
studies, on data collection, and on a discussion of the results of those studies.

A satellite can be the mechanism for establishing a computer utility serving an entire region or even a country. Computer terminals might be placed in all parts of the region and linked by satellite to a computer in a central location. For school use, terminals consisting of printers and readers capable of optically reading computer cards marked by students could be set up in classrooms and laboratories to allow students to engage in problem-solving activities.

It also is possible to use push-button telephone-like devices as computer terminals for some applications. Using the telephone dial to input information, for example, a student can use the computer to carry out numerical calculations, to do arithmetic drill exercises, to respond to multiple choice questions, or to request and hear computer-accessed audio tapes.

Students and teachers located in small school districts, whether in remote or urban areas, can have available to them the power of large, sophisticated computers for carrying out instructional projects and administrative activities. In this way, one or several computers could serve the needs of a large number of schools. By the use of the same terminals, school administrators can be provided with the current and historical information necessary for improving school management, planning, scheduling, and other administrative services.

These applications illustrate what can come about for education in the future. Satellites are the key to making the applications available to every school teacher and administrator.


GULF OF MEXICO
CARIBBEAN SEA
NORTH ATLANTIC OCEAN
ECUADOR
PERU
BRAZIL
BOLIVIA

While it is true that of all the options technology has placed before the educator, none since the invention of movable type has offered the satellite's promise to bring us to our long-cherished goal of equality of educational opportunity for all learners, wherever they might be. It would be naive and less than honest to pretend that the development of space-borne communications must usher in the educational millenium without at the same time creating problems as thorny as those it solves.

Among the first of the problems to come to mind is that of curriculum control, but with the satellite, as in most other cases, our initial fears may prove to be misdirected. It is altogether natural to think of a satellite as some super television transmitter high in the sky that rains down upon the just as well as the unjust a homogenized and sterilized curriculum prepared by an unnamed committee of bureaucrats, a curriculum to be swallowed meekly by everyone on whom it falls. If that were the true menace of the satellite, it would not be difficult to prevent its development and/or ignore its existence. But a satellite for education does not need to be a celestial authority that determines when each student shall learn about Newton's Second Law or what to believe about vital social issues.

The development of satellites comes at the same time as the development of inexpensive videotape recorders so that ITV programs transmitted from the bird can be stored on the ground and used (or ignored) at the discretion of the teacher and the learner. The combination of the two emerging technologies offers the promise of as great flexibility in the audiovisual media as the teacher now has in selecting textbooks for the classroom and the student has in selecting materials from the library. Since a satellite beam can be directed to any spot on the earth's surface from 22,300 miles above the equator, the satellite can bring resources to the rural school in Texas, Alaska, or the interior of Brazil as readily as to the schools in Westchester, Evanston, or Beverly Hills.

Chapter

Satellites in Orbit — Problems on the Ground 5

No, the satellite's promise and its challenge are far more subtle and complex than might be proposed by simplistic dreams of a super ITV station in the sky.

Another of the more obvious problems lies in the area of copyright. The beam from a satellite may cover as much as a third of the earth's surface and even with spot beams the potential audience for any satellite transmission will need to be measured in millions. These two facts make it clear that unless satisfactory arrangements with the owners of intellectual property can be obtained, conventional performance rights and copyright fees could so add to the economic burden of satellite transmission as to overwhelm the price of building and operating the technical aspects of the satellite system. In the end we might find that a communications satellite for education was merely a device to enable us to do, over a wide area and at a low unit cost, what we could no longer afford to do. In this country, consideration has been given for some years to revision of the 1909 United States Copyright Law. The Ad Hoc Committee [of education institutions and organizations] on Copyright Law Revision has continually urged that any legislation in the field provide "authority for nonprofit, noncommercial educational institutions to make reasonable use of a copyrighted work for nonprofit educational purposes without the need to obtain clearances or pay royalties for such use." It is obvious that it is essential for such a principle to be extended to satellite communications.

Further, the use of a satellite is likely to be governed not only by a domestic law but also by international copyright regulation as well. In the spring of 1971, the UNESCO Committee of Governmental Experts on Problems in the Field of Copyright and of the Protection of Performers, Producers of Phonograms, and Broadcasting Organizations Raised by Transmission via Space Satellites recommended that there be unlimited use of copyrighted materials via communications satellite for educational and research purposes. The goal of releasing the educational community from all copyright responsibility in the use of materials by satellite appears to be difficult to achieve but tempting to contemplate. The reality of the situation and the subtlety of the problem are more complex than a cursory examination would indicate. Consider, for instance, the matter of satellite spillover.

The term *spillover* refers to the fact that transmission from a satellite cannot be contained to fit precisely within the boundary of a target area. Even with the use of spot beam antennas, a weak signal will be received in adjacent areas. Spillover causes two particularly vexing problems. First, satellite transmissions are no respecters of international boundaries. In nations with a large land mass, such as the United States, it may be possible to deliver satellite transmissions aimed at Colorado or Kansas without substantial spillover into neighboring countries, but transmissions destined for California and Arizona or Montana and North

Dakota will surely cross into Mexico or Canada. International agreements that may be easy to obtain in North America may present far more difficult problems if satellites are to be used for education in the less developed countries in Asia and Africa.

The second problem — freeloading — will surely be present even when transmission can be limited to the domestic scene. It illustrates one reason why simple freeing from copyright laws might work against, as well as for, education's best interests. The problem existed long before the coming of the satellite. All producers of school television programs (and before them classroom radio broadcasts) have recognized that such programs are regularly used by viewers and listeners who do not contribute their share of financial support. While the problem is not new to the satellites, the problem's magnitude is so greatly increased with space-borne ITV and instructional radio that it may no longer be possible to regard freeloading as a minor annoyance. The technical requirement for an 8-foot antenna on the roof of the building might simplify the problem of identifying freeloaders, but it may also be necessary to ensure that our regulatory mechanisms are not so liberal as to deny the educator himself recourse to the law.

New satellite-based software may largely solve the problem of freeloading. Once again, the temptation to imagine the satellite as some kind of ultimate MPATI (Midwest Program on Airborne Television Instruction) would ignore the fact that satellites can offer entirely new opportunities for interactive instructional programing, specifically including computer-assisted instruction. To the extent that use of the satellite software requires two-way communication and not merely passive viewing, reception by unauthorized entities is reduced from freeloading to mere eavesdropping. It seems hardly likely that any school or individual would go to the trouble or expense of constructing a satellite receiving terminal merely to look over the shoulder at someone else's interactive learning with a computer.

Andrew R. Molnar examines "Critical Issues in Computer-Based Learning" in the August 1971 issue of *Educational Technology*. One of the problems that Dr. Molnar identifies is the need to develop systems of such scale that the necessary critical mass to release CAI's inherent cost benefits can be achieved. To date our experience clearly indicates that the more widespread a CAI system becomes, the greater is the proportionate cost of telecommunications interconnections to link the classroom or home terminals with the central computer. In all terrestrial communications technologies interconnection costs are directly proportional to the distance covered, but since satellite communications are independent of distance, satellites offer a genuine hope for the creation of large-scale CAI systems unburdened by cost-per-mile line charges.

Clearly, the most significant characteristic of the communications satellite is its ability

to provide the basis for large-scale systems encompassing communities of common interest that are independent of the traditional constraints of geography. That is to say, the satellite offers opportunities to provide new and needed services among scattered rural or urban environments that could not be adequately served by presently existing means. The problems of the ghetto school in Brownsville or Bedford-Stuyvesant are far more closely related to those of the schools in Roxbury and Watts than they are to the affluent suburban schools that surround their respective cities. Much present-day interinstitutional cooperation is based as much or more on common location as on common needs. Effective application of satellite systems not only requires that we cast off the parochial notion that every educational enterprise must work alone to solve its problems but also that we actively seek partners in common enterprises wherever they may be.

When new technology is introduced into the classroom, a problem often examined (although not always examined deeply enough) is the need for teacher training: "How shall we help teachers learn to make effective use of the new technology?" Whether the problem is seen as one of helping teachers with hardware or of assisting them in making effective use of new software, conventional views of teacher training are not likely to define accurately the true relationship between education and satellite.

The problems posed by the communications satellite are not merely those of copyright, spillover, institutional cooperation, new software, and the like. By far the most significant of all problems that the satellites propose is the need to rethink, in a very fundamental way, what it is that we are about. In freeing us from accidents of geography, which have long constrained our educational development and shaped our thinking, the communications satellite offers us fundamental challenges that go to the very heart of the educational enterprise. The satellite can be conceived as a new tool for facilitating our existing efforts, or it can be seen as a tool for building new enterprises to accomplish goals that were formerly beyond our grasp.

One example might be education for the children of migrant farm workers. To view the satellite as a means of improving our present efforts might suggest that a central computer linked by satellite to the administrative offices of each school system could be used to store all available data about each child of a migrant farm worker family. Thus, when Johnny's mother and father leave California's Imperial Valley at the end of the cotton season and move northward to harvest grapes near Fresno, Johnny's new teacher in Fresno would be able to retrieve from the central computer file all of the available data about his educational needs and progress, including his test scores on last week's spelling quiz in El Centro.

A different view of the potential of satellites might come from asking not, How can we use the satellite to improve the way the schools deal with migrant children? but, How can the satellite be used to improve the education of migrant children? The second question might lead us to design a satellite-based system in which not merely his records, but also his school follows Johnny north with the harvest season. Mobile classrooms with television sets, computer terminals, and all of the other devices needed to interface with the satellite might provide not merely an improved way of doing what we do now but also of addressing the problem directly. If there is value in such a system (and this is merely a hypothetical illustration), then it means establishing educational enterprises that cross traditional boundaries, not only of school districts, but also of states. Who would run such an enterprise? Who would pay for it? How would the work of Johnny and his new school be evaluated?

Satellites and their new technology will press important problems like these on education. If we consider the computer, the video cassette, cable communications, and satellites to be nothing more than ancillary devices to the traditional classroom, then it is likely that school boards and taxpayers will see them as more frills and gadgetry. If we view satellites as a threat because they require us to rethink our most cherished assumptions, we may be little different from blacksmiths who looked with horror upon the development of the automobile.

But if we look upon communications satellites as technology that, if wisely applied, can enable us to bring to rural villages or to inner-city slums new services and resources that can make equality of educational opportunity an achievable possibility rather than merely a hoped-for promise, then we will recognize the wisdom of the old adage that "problems are really opportunities looked at from the wrong end."

As it contemplates the use of satellites to bring information and instruction to people worldwide, the teaching profession is faced with several key policy questions.

1. *Should the profession seek the reservation of satellite space for educational purposes? If so, should it seek a specific number of channels for educational use or should it seek its own noncommercial educational satellite?*

There is considerable precedent in the United States for the noncommercial reservation by education of spectrum space. In the 1940's, public policy dictated that 20 percent of FM radio frequencies be set aside for educational and other noncommercial uses. In the 1950's, when new broadcast television channels were established, approximately 20 percent were likewise reserved for educational use. At the start of the 1970's the National Education Association recommended that the same 20 percent principle be applied in the development of cable television (CATV) for educational and public uses. The Federal Communications Commission (FCC) announced recently in its *proposed* rules and regulations for CATV that it would require each cable system to set aside, free of charge, one channel for educational use on a developmental basis for a five-year period. The NEA points out that the same urgency exists with respect to satellite communications as exists with cable communications.

Chapter

Policy Questions for the Profession 6

All of the many uses that the educational community will make of satellites cannot yet be predicted, but one fact is evident: one or two channels will not be sufficient to fulfill the many communications requirements of the schools of the late twentieth and early twenty-first centuries. It is also clear that a surprising number of commercial uses will quickly evolve and that hundreds of channels will be needed to handle business communications, computer data, and the legions of other very profitable and necessary communications needs of a complex society. If educators do not do the necessary advance planning, they cannot take for granted that satellite channels will be there waiting for public and educational use in the future. Education must make its voice heard *now,* while space is being allocated, or else education's options for the future will be foreclosed by other sectors.

2. *Should education be given free or reduced rates for satellite use?*

The American people have invested more than $20 billion in the space program. Communications satellite technology is a dividend from that investment. By using communications satellites instead of ground lines to interconnect their affiliated stations across the country, the three commercial TV networks have estimated that the costs to them of satellite interconnection would be about 60 percent of the cost of interconnection by ground lines. This represents a substantial saving to the networks, the bulk of which will accrue to private industry. The question arises, therefore, as to whether a part of these savings should not be used to provide the American people with a partial return on their investment in the form of free interconnection for public broadcasting and free rates for education's use. This would be a public dividend from the space program.

Some argue that there is no such thing as free service: if one user does not pay for service, payment must be obtained from other users or from the system operator's stockholders. Why should these other users be forced to underwrite the cost of service to schools and to public broadcasting? In answer, educators point out that the American public has already paid for the service and our people are entitled to a return on their investment, especially when one remembers that the schools, which belong to the people, are not profit-making institutions.

The NEA has urged the Federal Communications Commission to avoid writing into law anything regarding the development of satellite communications that would prevent carriers from rendering free or reduced-rate services to education for the use of satellite channels. In fact, carriers should be encouraged to give preferential treatment to education. But the question remains, Will they?

At present, education receives treatment not different from that accorded commercial interests in rate schedules for satellite transmission. Although satellites already make it possible to bring schools in Alaska, Hawaii, Guam, American Samoa, Puerto Rico, and other distant points of the United States in closer contact with the mainland, these possibilities are not yet reality because the rates for education's use of Intelsat commercial satellite facilities are totally out of the reach of education's ability to pay.

3. *Should restrictions be placed on the free flow of information in satellite communications? Is the broadest possible dissemination of information desirable? What about the unauthorized use of copyrighted materials on satellite transmissions?*

The question of free flow of information lies at the heart of any discussion of satellite communications. For years the United States has championed the concept of an open world, a world where the free flow of ideas and information is basic, a world where information flows freely among all peoples for their own welfare and education. UNESCO has stipulated that communications satellites should be used to promote the free flow of information and the universal dissemination of knowledge. Yet the issue is not as clear-cut as it may appear at first glance.

What about the rights of nations or states who do not want to receive transmissions from other nations? What about transmissions, intended for a given country, that spill over into neighboring countries? Should a country be permitted to disregard the objections of a target nation's government and beam whatever information it wishes into that nation? Would satellites not then become a propaganda tool extraordinary rather than an instrument of education and information?

E. Lloyd Sommerlad, Office of Free Flow of Information and International Exchanges, UNESCO, has put the problem this way:

> While satellites can, potentially, bring all parts of the world in closer touch with each other, it is evident that proximity is not in itself a guarantee of unanimity. As vehicles of opinion, radio and television broadcasts have enormous possibilities of offending sensibilities and of influencing public attitudes on matters of all kinds — political, religious, educational, and social. Under these circumstances, national legal provisions and existing international arrangements may soon prove inadequate to protect rights or prevent abuses in the space communications age.[1]

The concept of free flow of information has two dimensions—the rights of the author of the material being transmitted and the rights of the user of these copyrighted materials. Teachers are both authors and users. As authors, they want their own copyrighted materials protected against unauthorized and unlimited use, and they want to be compensated for such use; as teachers, they need limited reasonable access to copyrighted materials for purposes of teaching, scholarship, and research without the burden of undue restrictions imposed by the need to obtain clearances and pay royalties each time they (or their students) use these materials. What is needed, then, are U.S. and international copyright laws that are fair, just, and equitable for both the proprietor and the user. How can these laws become a reality? Current efforts to revise the present U.S. copyright law have been thus far heavily

[1] Address at Nice, France, Symposium of Satellites in Education. "The Use of Space Communications for Education and Development — Evolution and Prospects." May 1971.

weighted on the side of the proprietor. Unless modified, they would seriously hamper classroom practice as well as the use of materials and media for instructional purposes. If these same restrictions are applied to transmissions on communications satellites, as unquestionably they will be, policy questions in the area of copyright law revision will become a major barrier to the wide dissemination of information and materials via satellite.

The NEA is coordinating the work of an Ad Hoc Committee [of 43 educational organizations] of Copyright Law Revision, whose objective is to protect the public interest in the revision of the present U.S. Copyright Law, enacted in 1909, and in the revision of the Berne[2] and Universal Copyright[3] Conventions. Again, the teaching profession needs to discuss the issues and make its voice heard in the halls of Congress.

4. *If an educational satellite is planned, and eventually launched, who will manage and control it? Who will coordinate instructional programs to be broadcast by satellite?*

No organization presently exists whose purpose is to control and manage education's use of satellite space. Unlimited satellite space will *not* be available, and some group must serve as traffic cop or referee if equitable use of space by educational groups is to be achieved. This will be especially important if the decision is made to launch a noncommercial educational satellite (EDUSAT).

While the technical problems of satellite transmission have been practically solved, the political, financial, and legal problems continue to inhibit the full use of satellite capabilities. A coordinating agency is needed to give direction and guidance to the resolution of these problems.

Nationally, at least three options seem possible:

1. Designating a federal or quasi-federal agency, existing or new, as the manager of EDUSAT
2. Forming a public nonprofit consortium broadly representative of educational and public organizations and designating this consortium as the manager
3. Forming a public consortium as in "2" above, but contracting out the day-to-day operation of EDUSAT to a commercial firm to run it for the consortium.

Internationally, UNESCO would seem to be the logical choice for this management responsibility. If its charter

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[2] Berne Convention (International Copyright Union). This is the oldest and most experienced organization in the international copyright field. The Convention has 60 signatories, but does not include the United States, the Soviet Union, or the People's Republic of China.

[3] Universal Copyright Convention. This organization, originally sponsored by UNESCO, was set up in 1955 and has 58 members, many of whom overlap with membership on the Berne Convention. The United States is a member of UCC.

would not permit its assuming this role, then the World Confederation of Organizations of the Teaching Profession (WCOTP) might be another possibility.

5. *If instructional programs are planned for satellite transmission, does this mean eventually the establishment of a national — and someday, an international — curriculum?*

Such fears have haunted the educational community since the first suggestion was made that satellites might have a major role to play in education. There is a predictable apprehension on the part of many local school leaders that the satellite will impose a lockstep national or international curriculum upon the local school district and thus rob it of its autonomy. To the degree that local educators are not involved in determining what will be transmitted to and received from the satellite, there may be grounds for such fears. For the most part, however, these fears are unfounded because satellite programs are transmitted directly to regional or national ground stations and rebroadcast throughout the region or nation. The educational authority can then choose what programs he wishes to obtain and thus readily has a veto on what is shown on the screens under his control. Likewise, most programs distributed by satellite can be videotaped, stored in video libraries, and retrieved by individual teachers or learners upon call. The teacher or learner then becomes the gate keeper or control point.

6. *Is it reasonable to think in terms of statewide, regional, or even national efforts in program production?*

Because a satellite can see a third of the earth, the possibility of sharing resources over a large area makes imperative cooperation in program development and exchange of program materials. Whether these cooperative efforts are statewide, regional, national, or even international, experience has shown that they will likely be difficult to achieve because of the reluctance to give up local autonomy and the problem of reaching agreement between diverse interests, styles, cultures, and philosophies. Fortunately, however, there are national and international precedents for such cooperation. The Midwest Program on Airborne Television Instruction (MPATI) had considerable success in reaching consensus in program development over a six-state area in the 1960's. More recently, National Instructional Television (NIT) has had outstanding success with the organization of consortia of public school systems in the development of instructional televised series in art, health, and physical education.

Some clues as to how such cooperation might be brought about include the following:

1. Where a common curriculum does not exist, it might be possible to identify common elements in differing courses of study and produce program materials on these common elements.

2. A modular form of construction of the materials might be used, so that each learning package would be made up of separate elements that could be used separately, or in various combinations. In this way, the user could pick and choose which parts of an educational series he wanted to use and reorganize them in his own way.

3. Coproduction of specific materials might be undertaken by two or more school districts or consortia of districts.

4. Regional production centers might be established.

A satellite can never be made to conform to school bell schedules or to the tightly prescribed curriculums found in many school districts. In fact, this is one of its strongest features. Arthur C. Clarke, the British science writer, at a UNESCO space communication meeting in 1969, remarked:

A time is going to come when any student or scholar anywhere on earth will be able to tune in to a course in any subject that interests him, at any level of difficulty he desires. Thousands of educational programs will be broadcast simultaneously on different frequencies, so that any individual will be able to proceed at his own rate, and at his own convenience, through the subject of his choice.

This would result in an enormous increase in the efficiency of the educational process. Today, every student is geared to a relatively inflexible curriculum. He has to attend classes at fixed times, which very often may not be convenient.

The opening up of the electromagnetic spectrum made possible by educational satellites will represent as great a boon to scholars and students as did the advent of the printing press itself.

Communications satellites can thus be still another way to open up and emancipate learning. Satellites make us reexamine and reassess the flexibility and openness of our educational programs. Conceivably they will provide still another alternative to formal schooling as we know it, and will make possible more opportunities for individuals to learn on their own and will provide more options from which they can make choices. Eventually, through the use of direct broadcast satellites or mixed systems involving both satellites and terrestrial television or wire services, open universities of the air will become possible so that all individuals can learn wherever it is most convenient for them.

Satellites will also make possible —

- Links between schools and universities for guest lectures, forums, and exchange of research information.

- Long-distance exchange of data between libraries and research institutions.

- Linking of classrooms, teacher colleges, research centers, and regional educa-

tional laboratories for diagnosis and teaching.

- Teleconferences and long-distance seminars for groups of people who are continents apart.

Communications satellites, because they provide alternatives to formal schooling as we know it now, will force the education profession to reassess both its assumptions and its programs. Because communications satellites make possible the emancipation of learning by bringing better education to more people . . . because more people will be able to learn when, what, where, and how they want, the teaching profession must make a fundamental policy decision. Will it work to facilitate this movement toward an open education for all, or will it continue a rigid advocacy of the idea of the Little Red Schoolhouse?

Eventually, through cooperative production arrangements, it will be possible to consider local, state or regional, national, and possibly international aspects of each subject in the school curriculum. The division of labor between production centers at each level can bring about a team approach to the development of satellite programs nationwide — and eventually worldwide. Determining what can best be done locally, what regionally, what nationally, or what internationally — these are key questions of policy to be considered, with each level producing what it can produce most uniquely as part of a total team effort.

The emphasis in satellite communications for schools should be on the sharing of excellence and diversity rather than the dissemination of mediocrity and uniformity. Not only can the satellite distribute high quality programs produced nationally, but it should also facilitate the exchange of locally and regionally produced programs of high quality. As such, it should become a means of fostering the pluralistic tastes and individual specializations of local schools, thus making possible a variety of voices, rather than a single voice, on a given topic. How best to achieve the proper balance between local, regional, and national programs is a key problem in making satellites work for education.

APPENDIX

A. Glossary

Antenna Gain: The increase in signal strength resulting from a directional antenna's ability to multiply the effective strength of the transmitted or received signal.

Directional Antenna: A transmitting antenna that concentrates its energy primarily in one direction exactly as a reflector in a spotlight focuses the energy of the light bulb. Receiving antennas may also be directional, using a reflector to focus energy received over a large area and concentrated at the reception point.

Dish: A slang term for a parabolic reflector, the major element in the type of directional antenna most often used in space communications.

Downlink: The transmission of a signal from a satellite to earth.

Earth Terminal: A terrestrial installation that can transmit and/or receive signals from one or more communications satellites. The components of a satellite system include one or more earth stations, one or more space stations (the satellite or satellites), and one or more earth terminals capable of receiving signals from the satellites.

Effective Radiated Power (erp): The use of a directional antenna, and the subsequent benefits of antenna gain mean that a transmitter may deliver to the target area the same amount of power as would be delivered by a much stronger transmitter without a directional antenna. Thus a 20-watt transmitter, connected to a directional antenna, might deliver as strong a signal as a 1,000-watt transmitter. Its transmitter power output (TPO) would still be 20 watts but the use of a directional antenna with an antenna gain of 50:1 would give it an effective radiated power of 1,000 watts.

Equivalent Isotropic Radiated Power (eirp): The same effective advantage from the use of a directional antenna, described as erp in terrestrial FM and television broadcasting, is designated for communications satellites as eirp or "equivalent isotropic radiated power." Terrestrial broadcast engineers use "erp" while "eirp" is used by space scientists. The two terms mean exactly the same thing.

Geostationary Orbit: If a satellite is placed at synchronous altitude above the earth's equator, it will remain stationary in relation to any point on the surface of the earth below. Sending and receiving earth terminals can thus be aimed at a fixed point and need not to track the satellite.

Low-Altitude Elliptical Orbit: A satellite, the orbit of which is subsynchronous and such that one end of the orbit (the perigee) is nearer the earth and the other (the apogee) further away.

Satellite: Literally any celestial body rotating around another body, as the moon around the earth and the earth around the sun. Artificial satellites are spacecraft put into orbit around the earth by man.

Spillover: Much energy delivered by a satellite to areas beyond those for which the signal is intended. Early communications satellites with less sophisticated antennas radiated signals that missed the surface of the earth entirely. Even with contemporary directional antennas, some part of the signal may impinge on other states or nations for which the communications are not intended. Spillover may create potential interference with existing terrestrial communications systems and may also present problems of possible use of satellite signals by those for whom the communications are not intended.

Synchronous Altitude: The height of the satellite above the earth determines the period of its revolution about the planet. At 22,300 miles, the time it takes the satellite to make one complete revolution around the earth is equal to approximately 23 hours and 56 minutes, the time it takes the earth to make one rotation on its axis. The revolution of the satellite about the earth is thus synchronized with the earth's rotation.

Tracking: As an observer on the ground might watch an airplane fly by overhead, turning his head and body to keep the plane in view as it moves from one horizon to the other, so satellite earth terminals track satellites as their position changes relative to the earth. Communications satellites in synchronous orbit maintain a fixed position relative to the earth and do not require earth stations that can track them.

Transponder: An input/output device (I/O) on board a satellite that receives uplink transmissions from the earth and amplifies and retransmits them (downlink) to other earth terminals.

Uplink: The transmission of a signal from the earth to a satellite.

B. A Synopsis of the Evolution of Communications Satellites

Satellite	Launch Date	Comment
Score	December 12, 1958	First U.S. communications satellite; transmitted President Eisenhower's Christmas greetings
Echo I	August 12, 1960	First television picture transmitted on April 26, 1962, from California to Massachusetts
Courier	October 4, 1960	First space photograph transmitted in October 1960 between Deal, New Jersey, and Salinas, Puerto Rico
Telstar I	July 10, 1962	First reliable trans-Atlantic television transmission
Relay I	December 13, 1962	First satellite to relay trans-Pacific television
Syncom II	July 26, 1963	First successful synchronous satellite
Early Bird (Intelsat I)	April 6, 1965	First commercial communications satellite; 240 voice circuits, or 1 TV channel
Intelsat IV	January 25, 1971	9,000 two-way telephone circuits or 12 TV channels
ATS-I	1966	In March 1971, voice broadcasts for educational purposes in Hawaii and pan-Pacific area; discussion sessions among teachers and administrators in 16 villages in Alaska in the fall of 1971

ATS-III	1967	Lectures, seminars, and data exchange experiments between Stanford University and Brazil in April 1971
ATS-F	May 1973	NASA/DHEW/CPB to conduct various educational experiments in Rocky Mountain area, Appalachia, and Alaska in 1973-74; instructional TV broadcasts in India, spring 1974; the NEA has proposed an in-service teacher training experiment
ATS-G	1975	A variety of educational experiments have been proposed by the California and Florida State Departments of Education

C. Sources for Further Reading

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D. Principal Organizations Concerned with Satellite Technology

Center for Development Technology
Box 1196
Washington University
St. Louis, Missouri 63130

Commissioner for Education
Federal Communications Commission
1919 M Street, N.W.
Washington, D.C. 20554

Communications Satellite Corporation
Information Office
950 L'Enfant Plaza, S.W.
Washington, D.C. 20024

EDSAT Center
Space Science and Engineering Center
1225 West Dayton Street
Madison, Wisconsin 53706

Joint Council on Educational Telecommunications
1126 Sixteenth Street, N.W.
Washington, D.C. 20036

National Education Association
Division of Instruction and Professional Development — Educational Technology
1201 Sixteenth Street, N.W.
Washington, D.C. 20036

National Center for Educational Technology
U.S. Office of Education
Department of Health, Education, and Welfare
Washington, D.C. 20202

Office of Space Science and Applications
National Aeronautics and Space Administration
Washington, D.C. 20546

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